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POWER PLANT ENGINEERING

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Cover: Systematically designed boiler room control panel for a utility power plant. Photo, courtesy, Leeds & Northrup Co.

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INSULATION—

How to Install It

Preparation of surface, details of installation, application of finish, for mineral wool blankets, blocks, insulating cement and pipe insulation for heated industrial equipment

THE FOLLOWING DATA on how to install various types of insulating materials represent recommended practice at the present time. They form the major portion of a recently-published standard on this subject issued by the National Bureau of Standards, U. S. Department of Commerce; the work was undertaken at the instance of the Industrial Mineral Wool Institute. The recommendations have been approved by a large number of users and manufacturers, have just been issued as Commercial Standard CS 117-44, and are effective for new production from May 25, 1944.

It is to be understood that the setting up of these standards is a purely voluntary effort, on the part of all those interested, to establish minimum standards, avoid misunderstandings and provide a basis for certifying quality of material and installation. The U. S. Department of Commerce has no regulatory power to enforce them and the Bureau of Standards merely acts as an unbiased co-ordinator through which all interested parties can agree on the practices found most satisfactory to all.

The standards are written in the form of specifications, which can be incorporated in agreements when desired or can be referred to, and the original text of the standards has been largely retained here. However, the following represents only a portion of

*A copy of CS 117-44 may be obtained without charge upon written request to the Industrial Mineral Wool Institute, 441 Lexington Avenue, New York 17, N. Y., or from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., for 10 cents per copy.

Table 1.—Types, conductivities, classes and sizes of mineral wool products

Types	k at °F mean temperature			Maximum temperature limit		Sizes
	200	300	400	Class	°F	
Blanket.....	0.41	0.47	0.53	B..... C.....	1,000 1,200	1 to 6 in. thick by 24 in. wide by 48 in. or 96 in. long.
Blocks.....	0.50	0.53	0.56	A..... C..... D.....	800 1,200 1,600	1 to 4 in. thick by 6 in. or 12 in. wide by 18 in. or 36 in. long.
Cement.....	0.70	0.75	0.80	C..... E.....	1,200 1,800	Packaged in 50-lb. bags.
Pipe insulation (blanket-type).....	0.41	0.47	0.53	B..... C.....	1,000 1,200	1 to 4 in. thick by 24 in. long fabricated to fit 2 in. and larger pipe.
Pipe insulation (molded-type).....	0.42	0.46	0.50	A..... C.....	800 1,200	½ to 4 in. thick by 36 in. long to fit ½ to 12 in. and larger steel pipe sizes.

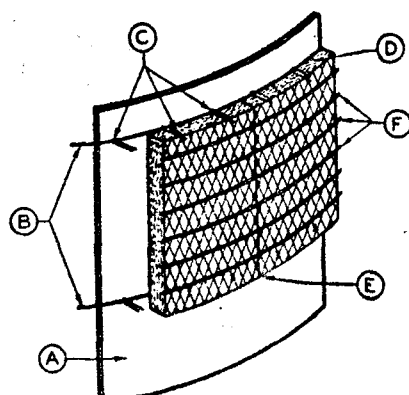


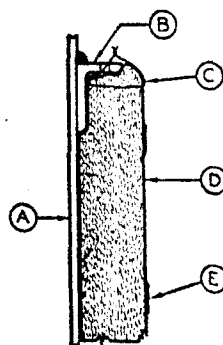
Fig. 1.—Method of securing mineral wool blankets on curved surfaces.

A, Bare surface; B, No. 9-gage galvanized wire girdles pulled tight around curved surfaces, spaced 4 ft on centers; C, blankets affixed to No. 9-gage girdles with No. 16-gage galvanized hairpin wires, 12 in. on centers; D, blanket insulation with expanded lath side exposed; E, blanket edges laced with No. 16-gage galvanized wires; F, blankets secured with ½- or ¾-in. galvanized bands spaced approximately 8 in. on centers.

the standards and anyone desiring to use them should obtain a complete copy.*

The standards begin with a discussion of the requirements for the composition of insulation, its thermal conductivity, denoted by k, in Btu per hr per sq ft per deg per 1-in. of thickness and the maximum temperature limits to be recommended by the manufacturers for various classes of insulation. These data are summarized in Table I. The standard sizes noted are subject to tolerances discussed in the text. Most of the above points are primarily of concern to manufacturers but many

Fig. 2. Alternate method of affixing mineral wool blankets



A, Bare surface; B, punched clip angles welded to surface, spaced 8 ft on horizontal centers; C, blankets hung temporarily from angles with No. 12-gage galvanized wires; D, blanket insulation 1 in. thicker than outstanding leg of angle; E, blanket secured with ½- or ¾-in. galvanized bands space approximately 8 in. on centers.

must also be taken into account by engineers who write specifications. The standards provide that certain characteristics of the material are to be determined by ASTM test methods readily available in published form.

The following represents recommended installation requirements, based upon long experience, for maximum service in the use of mineral wool products for insulating heated industrial equipment.

Auxiliary Material

Finishing cements may be used to provide a smooth, hard surface over insulating materials in locations not subject to excessive moisture or abrasion.

Table II.—Molded-type pipe insulation
Thicknesses a for standard-weight steel-pipe sizes

Pipe size		Standard thickness	Double standard thickness
Nominal	Actual O. D.		
¾ in.	0.840	1 1/4 in.	2 1/4 in.
1 in.	1.050	1 1/2 in.	2 1/2 in.
1 1/4 in.	1.315	1 3/4 in.	2 3/4 in.
1 1/2 in.	1.600	1 3/4 in.	2 3/4 in.
2 in.	1.900	1 3/4 in.	2 3/4 in.
2 1/2 in.	2.375	1 3/4 in.	2 3/4 in.
3 in.	2.875	1 3/4 in.	2 3/4 in.
3 1/2 in.	3.500	1 3/4 in.	2 3/4 in.
4 in.	4.000	1 3/4 in.	2 3/4 in.
4 1/2 in.	4.500	1 3/4 in.	2 3/4 in.
5 in.	5.000	1 3/4 in.	2 3/4 in.
6 in.	6.625	1 3/4 in.	2 3/4 in.
7 in.	7.625	1 3/4 in.	2 3/4 in.
8 in.	8.625	1 3/4 in.	2 3/4 in.
9 in.	9.625	1 3/4 in.	2 3/4 in.
10 in.	10.750	1 3/4 in.	2 3/4 in.
11 in.	11.750	1 3/4 in.	2 3/4 in.
12 in.	12.750	1 3/4 in.	2 3/4 in.
14 and up		1 3/4 in.	2 3/4 in.

a In addition to the thicknesses specified above, molded-type pipe insulation may be manufactured in thicknesses of 1, 1 1/4, 2, 2 1/4, 3, and 4 in. for all nominal pipe sizes.

b These pipe sizes are no longer listed as standard for steel pipe, Simplified Practice Recommendation R57-32.

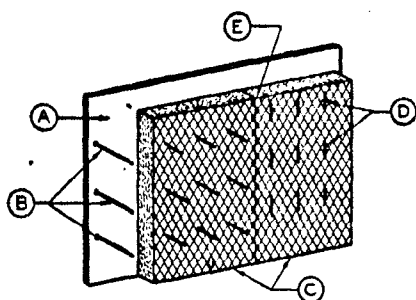


Fig. 3 Alternate method of affixing mineral wool blankets on flat surfaces.

A, Bare surface; B, No. 9-gage galvanized wires of specified length welded perpendicular to surface, spaced approximately 8 in. on centers; C, blankets impaled on No. 9-gage galvanized wires with expanded-lath side exposed; D, No. 9-gage galvanized wires bent up and pressed into the blankets; E, blanket edges laced with No. 16-gage galvanized wires.

Asphaltic weatherproof finish may be used to provide a water-tight protective finish over insulating materials

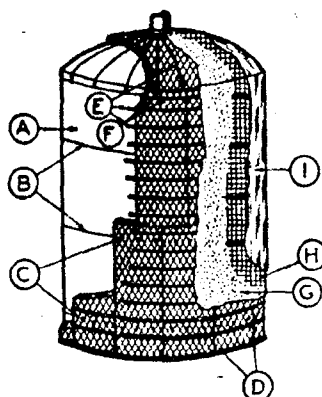


Fig. 4. Application of mineral wool blanket insulation on curved surfaces.

A, Bare surface; B, No. 9-gage galvanized wire girdles spaced 4 ft. on centers; C, blanket insulation 2 ft. by 8 ft., wired to girdles; D, blanket edges laced with No. 16-gage galvanized wires; E, 1/2- or 3/4-in. galvanized bands spaced approximately 8 in. on centers; F, two or more bands at top; G, insulating cement; H, 1-in. galvanized wire netting secured in place with No. 16-gage galvanized wires; I, finishing cement or asphaltic finish.

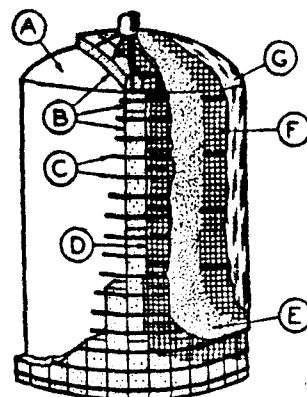


Fig. 5. Application of mineral wool block insulation on curved surfaces

A, Bare surface; B, mineral wool blocks applied with joints staggered; C, 1/2- or 3/4-in. galvanized bands spaced approximately 8 in. on centers; D, 1-in. galvanized wire netting secured in place with No. 16-gage galvanized wires; E, insulating cement; F, 1-in. galvanized wire netting secured in place with No. 16-gage galvanized wires; G, finishing cement or asphaltic finish.

Table III—Recommended minimum insulation thicknesses

The insulation thicknesses listed in this table are recommended for indoor locations; for outdoor location increase insulation thickness not less than 1/2 in. For under ground application, thickness may be decreased 1/2 in. when specified.

BLANKET INSULATION			
Temperature °F	Thickness in.	Temperature °F	Thickness in.
Up to 300	1	700 to 900	2 1/2
300 to 500	1 1/2	900 to 1,100	3
500 to 700	2	1,100 to 1,200	3 1/2

BLOCK INSULATION			
Temperature °F	Thickness in.	Temperature °F	Thickness in.
Up to 200	1	Up to 200	1 1/2
200 to 400	1 1/2	200 to 400	2 1/2
400 to 500	2	400 to 500	3
500 to 600	2 1/2	500 to 600	3 1/2
600 to 700	3	600 to 700	4
700 to 900	3 1/2	700 to 900	4 1/2
900 to 1,100	4	900 to 1,100	5
1,100 to 1,300	4 1/2	1,100 to 1,300	5 1/2
1,300	5	1,300	6 1/2

1 Usually applied over blankets and blocks 1/2 in. thick as a base coat for desired finish. For built-up applications on irregular surfaces, thicknesses may be used up to the practical limit.

in locations where excessive moisture or abrasion are encountered or wherever else specified within its temperature limit. This asphaltic finish shall consist of a fibrated asphalt emulsion, which, for weatherproofing purposes, shall be applied to a minimum dry thickness of 1/8 in.

Miscellaneous accessory materials†, such as adhesives, attachment devices, canvas, paper, metal fabrics, asbestos-cement sheets, roofing felt, paint, sheet metal, etc., shall be of a type and quality satisfactory for use in the applications hereinafter described.

Application (General)

Selection of the economical thickness of mineral wool insulation to be installed is governed largely by the operating temperature maintained, the cost of heat delivered, the number of hours operated per year, and by the effectiveness and applied cost of the

†During the war emergency period, some of the auxiliary material described in this standard may be considered critical. When such auxiliary materials are not available owing to Government order, an acceptable alternate material shall be used.

PIPE INSULATION

Blanket-type				Molded-type			
Temperature °F	Thickness			Temperature °F	Thickness		
	Pipes 2 in. to 4 in.	Pipes 4 in. to 6 in.	Pipes 6 in. and up		Pipes below 2 in.	Pipes 2 in. to 4 in.	Pipes 4 in. and up
150 to 250	1 in.	1 in.	1 in.	Up to 275	Std.	Std.	Std.
250 to 350	1 1/2	1 1/2	1 1/2	275 to 350	do.	do.	1 1/2 in.
350 to 450	1 1/2	1 1/2	1 1/2	350 to 425	do.	do.	2 in.
450 to 550	1 1/2	1 1/2	1 1/2	425 to 500	1 1/2 in.	2 in.	Dbl. std.
550 to 650	1 1/2	1 1/2	1 1/2	500 to 600	2 in.	Dbl. std.	Do.
650 to 750	1 1/2	2	2	600 to 750	2 1/2 in.	3 in.	3 in.
750 to 900	2	2 1/2	2 1/2	750 to 900	2 1/2 in.	3 1/2 in.	3 1/2 in.
900 to 1,050	2	2 1/2	2 1/2	900 to 1,050	2 1/2 in.	3 1/2 in.	4 in.
1,050 to 1,200	2 1/2	3 1/2	4	1,050 to 1,200	2 1/2 in.	3 1/2 in.	4 1/2 in.

insulation. Other factors that determine insulation thickness are the maintenance of precise temperature control; protection against damage by corro-

sion, freezing, or fire; and personal safety of workmen.

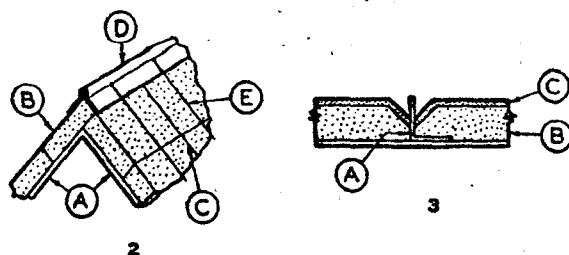
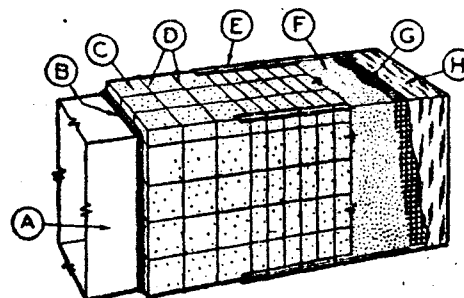
The insulation thicknesses to be applied for various operating conditions

Fig. 6. Application of mineral wool blocks on flat or rectangular surfaces.

Sketch 1: Application where insulation thickness is greater than stiffener height. A, bare surface; B, stiffener ribs; C, mineral wool blocks; D, No. 16-gage galvanized reinforcing wires or 1/2-in. galvanized bands applied over blocks; E, corner bead secured over blocks at corners with No. 16-gage galvanized wires; F, insulating cement; G, 1-in. galvanized wire netting stretched tightly over insulating cement and wired in place; H, finishing cement or asphaltic finish.

Sketch 2: Enlarged details showing application of corner bead. A, metal duct; B, mineral wool blocks; C, No. 16-gage galvanized wire over blocks; D, corner bead; E, No. 16-gage galvanized wires drawn through perforations in corner bead.

Sketch 3: Application where insulation thickness is equal to or less than stiffener height. A, stiffener; B, mineral wool blocks; C, insulating cement and specified finish beveled back at rib.



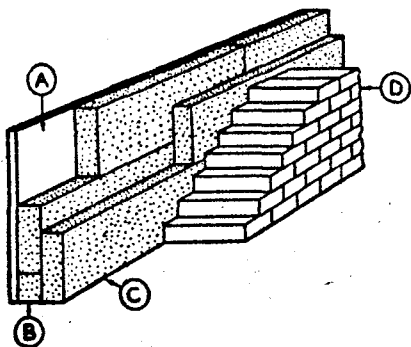


Fig. 7. Application of mineral wool blocks between structural supports

A, bare surface; B, first layer of mineral wool blocks against steel casing; C, second layer of blocks applied with all joints staggered; D, brick.

shall not be less than those recommended in Table III, unless otherwise approved by the purchaser.

External surfaces of heated multi-layer brick constructions shall be insulated to a thickness no greater than that which will result in a safe temperature gradient for all materials used in the composite construction.

Expansion joints for insulation shall be provided on equipment operated at temperatures above 600 F, as specified by the insulation manufacturer or by the applying contractor.

Adequate protection shall be provided to prevent the entrance of moisture into the insulating material. Particular care shall be taken around openings and connections.

All mineral wool insulating products and accessory materials shall be installed in a neat, workmanlike manner in accordance with the following recommendations and subject to the approval of the purchaser.

Blanket Insulation

Preparation of surface—The surface to be insulated shall be carefully inspected and all loose rust, scale, or dirt removed and leaks or damage repaired. Suitable anchorage for the blankets shall be provided in the form of wire cables, nuts, clip angles, or No. 9-gage galvanized wires, welded or otherwise, securely affixed to the surface on specified centers.

Installation of blankets—On curved surfaces, blankets of specified thickness as in Table III, shall be secured to the supports in the manner shown in Figs. 1, 2, and 4.

On flat surfaces, blankets shall be applied with the expanded lath exposed as in Fig. 3.

Application of finish—After the blankets are in position and carefully secured, a ¼-in. layer of mineral wool insulating cement shall be applied. This coat shall be forced well into the expanded metal lath to form a strong key. Sufficient cement shall be applied to level off the surface. A second ¼-in. troweled coat of insulating or finishing cement shall be applied after the first coat has dried. Portland cement may be added to this coat to provide a harder finish.

Insulation located indoors and not

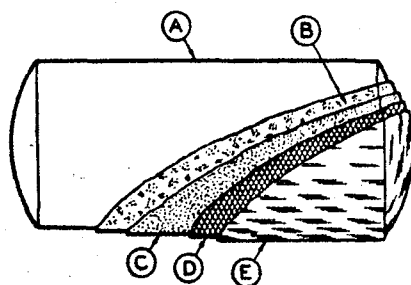


Fig. 8. Application of mineral wool insulating cement on curved steel surfaces.

A, cleaned bare surface; B, first coat of insulating cement spotted on roughly by hand; C, second coat of insulating cement; D, 1-in. galvanized wire netting; E, finishing cement or asphaltic finish.

exposed to moisture or abrasion may be further finished as described below.

(1) When specified, a 6- or 8-oz. canvas jacket shall be sewed or pasted smoothly in place. If sewed, stitches shall be spaced not more than ½ in. apart, with seams located where least visible.

(2) When specified, a layer of asphaltic weatherproof finish may be applied instead of canvas. After the second coat of cement has thoroughly dried, 1-in. galvanized wire

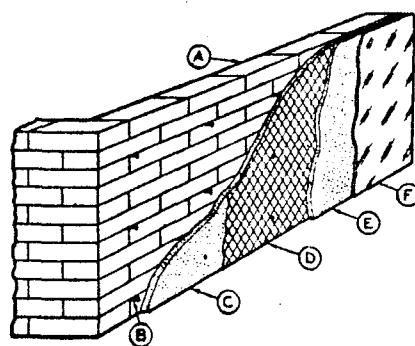


Fig. 9. Application of mineral wool insulating cement on brick surfaces.

A, brick wall; B, masonry nails spaced 8 to 12 in. on centers, extending approximately ¼ in. from bricks; C, first coat of insulating cement applied nearly flush with nail heads; D, 1-in. galvanized wire netting secured to nail heads; E, second coat of insulating cement; F, finishing cement or asphaltic finish.

netting shall be stretched tightly over the surface and wired in place with No. 16-gage galvanized wire. Asphaltic finish shall then be applied sufficiently thick (approximately ¼ in. thick, wet) to provide a minimum dry thickness of ⅜ in., troweling it well into the wire netting.

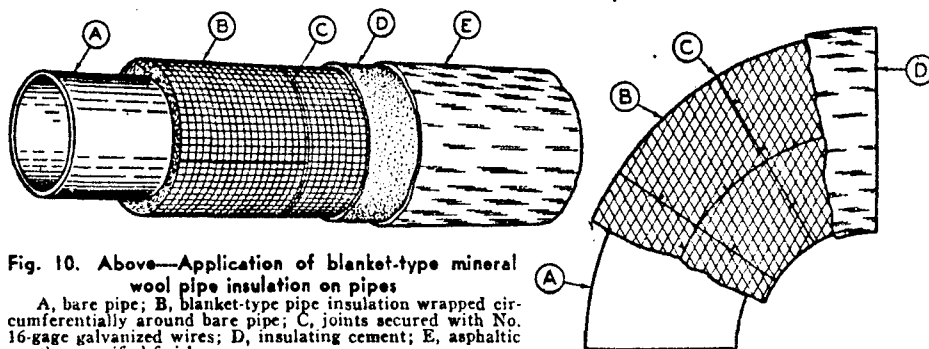


Fig. 10. Above—Application of blanket-type mineral wool pipe insulation on pipes

A, bare pipe; B, blanket-type pipe insulation wrapped circumferentially around bare pipe; C, joints secured with No. 16-gage galvanized wires; D, insulating cement; E, asphaltic or other specified finish.

Fig. 11. Right—Application of blanket-type mineral wool pipe insulation on large valves and fittings

A, bare fitting; B, blanket-type pipe insulation; C, joints secured with No. 16-gage galvanized wires; D, insulating cement or other specified finish.

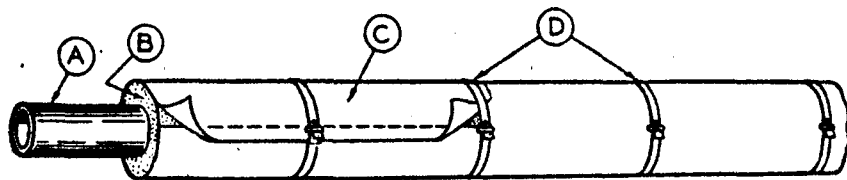


Fig. 12. Application of mineral wool sectional pipe insulation single-layer

A, bare pipe; B, sectional pipe insulation; C, canvas jacket or other specified finish; D, metal bands.

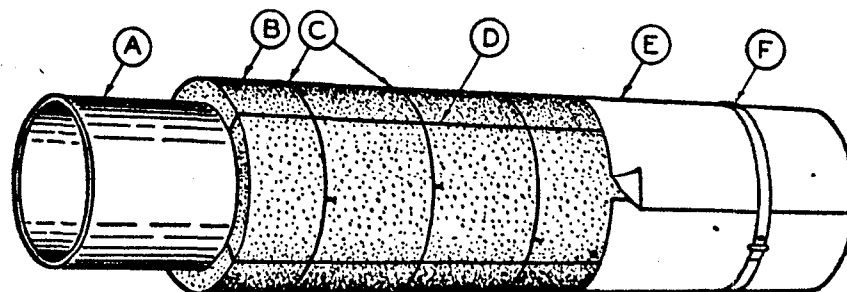


Fig. 13. Application of mineral wool segmental pipe insulation

A, bare pipe; B, segmental pipe insulation; C, No. 16-gage galvanized wires; D, insulating cement when required; E, canvas jacket or other specified finish; F, metal bands.

Insulation located *outdoors* or exposed to moisture or abrasion shall be protected by one of the methods described below.

(1) After the cement has thoroughly dried, 1-in. galvanized wire netting shall be stretched tightly over the surface and wired in place with No. 16-gage galvanized wire. Asphaltic finish shall then be applied sufficiently thick (approximately $\frac{1}{4}$ in. thick, wet) to provide a minimum dry thickness of $\frac{1}{8}$ in., troweling it well into the wire netting.

(2) When specified on smooth regular surfaces, the cement and asphaltic coatings may be omitted, and the surface weatherproofed instead with a sheet-metal jacket. The sheet-metal jacket shall be no lighter than No. 28 gage, single or double galvanized, suitably anchored to the surface. Seams shall be lapped 2 in. against the weather and secured with metal screws, or provided with a locked or flange-crimped joint or otherwise sealed, to prevent the entry of moisture. After providing for expansion and contraction of the metal jacket, it shall be secured in place with $\frac{1}{2}$ -in. or $\frac{3}{4}$ -in. galvanized metal bands, machine-stretched and crimped, on specified centers.

Block Insulation

Preparation of surface—The surface to be insulated shall be carefully inspected and all loose rust, scale, or dirt shall be removed and leaks or damage repaired. Brick surfaces shall be made true and even.

Suitable anchorage or support for the blocks shall be provided when required, by securely affixing wire cables, nuts, clip angles, or rods to the surface on specified centers.

Installation of blocks—On *curved* surfaces, blocks of specified thickness (see Table III) shall be applied using staggered joint construction as shown in Fig. 5.

On *flat* surfaces, blocks shall be applied by the methods shown in Fig. 6. When blocks are installed between brick or other structural supports, the anchors, insulating cement, and other finish shall be omitted. See Fig. 7. Finish is to be applied by the same methods given above for blanket insulation.

Insulating Cement (Built-up Applications)

Preparation of surface—The surface to be insulated shall be carefully inspected and all loose rust, scale, or dirt removed and leaks or damage repaired. Paint or grease shall be removed with a caustic solution which shall then be washed off with water.

Anchorage for the insulating cement shall be provided as required, in the form of clip angles, nuts, rods, or masonry nails of proper size. Additional support is recommended for insulating cement applied on light-gage metallic surfaces, or when surface expansion and contraction is excessive.

When possible, the surface to be insulated shall be kept hot to facilitate drying.

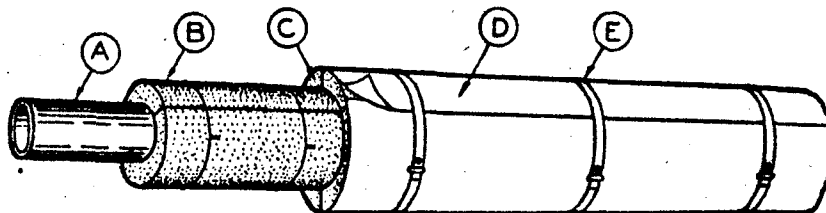
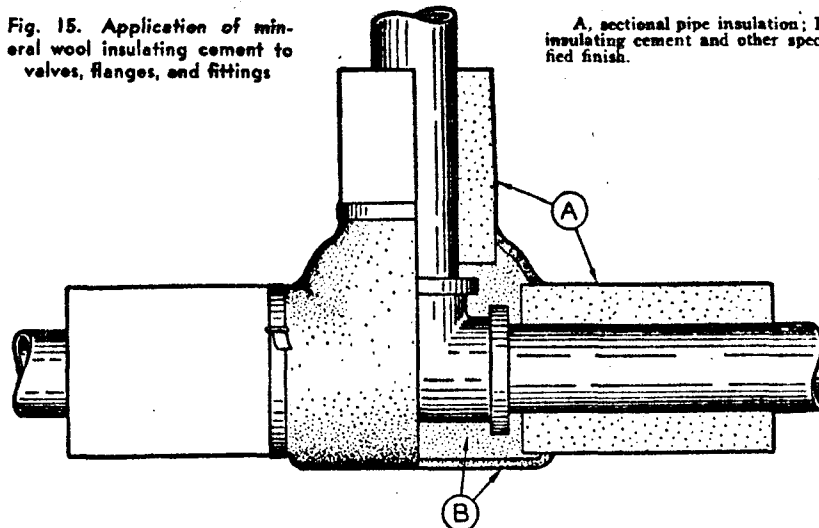


Fig. 14. Application of mineral wool sectional pipe insulation, double-layer
A, bare pipe; B, first layer secured with No. 16-gage galvanized wires; C, second layer applied with all joints staggered; D, canvas jacket or other specified finish; E, metal bands.

Fig. 15. Application of mineral wool insulating cement to valves, flanges, and fittings



A, sectional pipe insulation; B, insulating cement and other specified finish.

Installation of insulating cement—Insulating cement shall be mixed with clean fresh water to troweling consistency before application.

On *curved* or *flat* steel surfaces, insulating cement of specified thickness (see Table III) shall be built up in separate coats not greater than $\frac{3}{4}$ in. thick as in Fig. 8.

(1) A reinforcing layer of 1-in. galvanized-wire netting shall be applied between every second coat of insulating cement, stretched tightly over the dry cement and securely wired in place with No. 16-gage galvanized wire when: (a) the total insulation thickness specified is greater than 1 in., (b) the cement is to be applied to the underside of equipment, (c) the insulated equipment will be subjected to vibration.

On heated brick surfaces, insulating cement shall be applied as in Fig. 9.

If the insulated surface is to be weatherproofed, No. 16-gage galvanized hairpin wires shall be affixed to the nail heads and permitted to extend through the second layer of insulating cement to provide anchorage for the weatherproof finish.

Application of finish—Insulating cement located *indoors* and not exposed to moisture or abrasion shall be finished, when specified, with a $\frac{1}{4}$ -in. troweled coat of finishing cement. Portland cement may be added to provide a harder finish.

(1) When specified, a 6- or 8-oz canvas jacket shall be sewed or pasted smoothly in place. If sewed, stitches shall be spaced not more than $\frac{1}{2}$ in. apart, with seams located where least visible.

(2) When specified, a layer of

asphaltic weatherproof finish shall be applied instead of canvas. After the cement has thoroughly dried, 1-in. galvanized wire netting shall be stretched tightly over the surface and wired in place with No. 16-gage galvanized wire. Asphaltic finish shall then be applied sufficiently thick (approximately $\frac{1}{4}$ in. thick, wet) to provide a minimum dry thickness of $\frac{1}{8}$ in., troweling it well into the wire netting.

Insulating cement located *outdoors*, or exposed to moisture or abrasion, shall be finished with an asphaltic weatherproof finish.

(1) A $\frac{1}{4}$ -in. coat of finishing cement shall be applied when specified, to which Portland cement may be added to provide a harder finish.

(2) After the cement has thoroughly dried, 1-in. galvanized wire netting shall be stretched tightly over the surface and wired in place with No. 16-gage galvanized wire. Asphaltic finish shall then be applied sufficiently thick (approximately $\frac{1}{4}$ in. thick, wet) to provide a minimum dry thickness of $\frac{1}{8}$ in., troweling it well into the wire netting. (See Figs. 8 and 9.)

Blanket-type Pipe Insulation

Installation on pipes—Blanket-type pipe insulation of specified thickness (see Table III) shall be applied on pipes and long radius bends of 2-in. diameter or greater.

(1) Before applying, the insulation shall first be formed roughly to fit the pipe. Pipe insulation shall be spaced a sufficient distance from flanges to permit removal of the bolts when flanges are opened. Adjacent lengths shall be butted closely to-

Fig. 16. Application of mineral wool block insulation to large fittings.

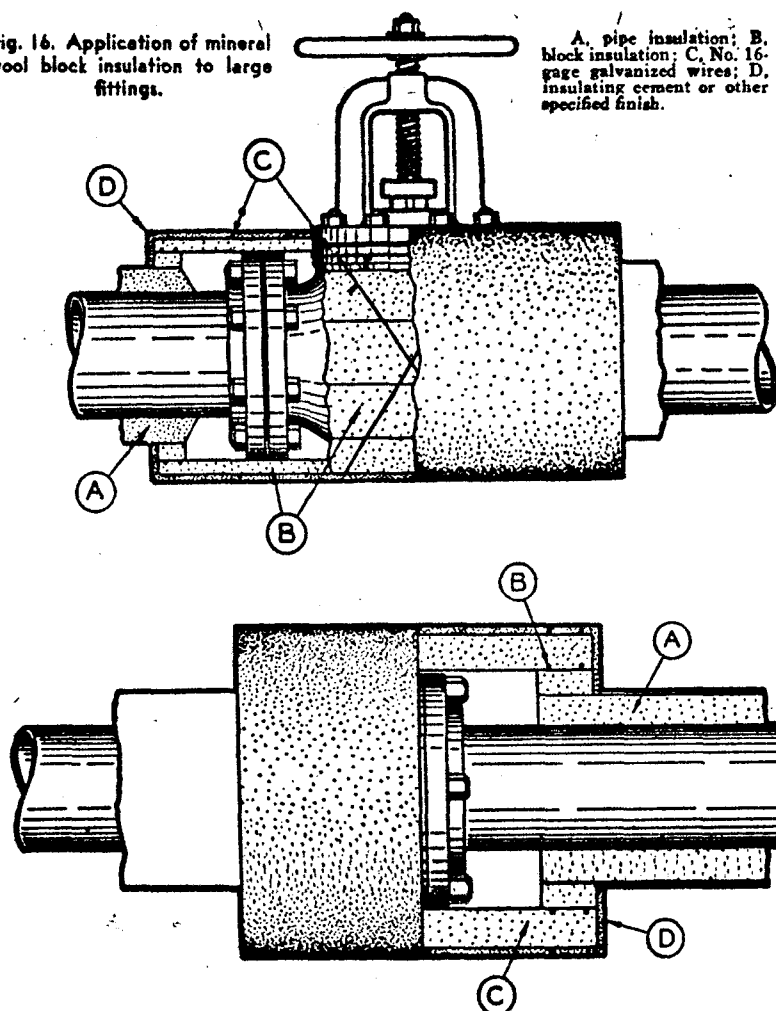


Fig. 17. Application of molded-type mineral wool pipe insulation to flanges and fittings. A, sectional pipe insulation; B, No. 16-gage galvanized wires or galvanized bands; C, sectional or segmental pipe insulation; D, insulating cement or other specified finish.

gether and laced with No. 16-gage galvanized wire. The ends of wire loops shall be bent over and pressed into the insulation to leave no sharp projections. (See Fig. 10.)

(2) When specified, blanket-type pipe insulation shall be furnished with an integral galvanized-metal jacket. It shall be applied snugly around the pipe and bolted along the flanged longitudinal joint. No further finish is required.

Installation on valves, flanges, and fittings—Valves, flanges, and fittings 6 in. in diameter or larger shall be insulated with blanket-type pipe insulation of thickness equal to insulation on adjacent piping. The insulation shall be formed to fit by cutting it along the circumferential edges, then secured in place by wiring the longitudinal joint. All cut edges shall be laced together with No. 16-gage galvanized wire and the ends of wire loops bent over and pressed into the insulation to leave no sharp projections. (See Fig. 11.)

As alternate applications on valves, flanges, and fittings, insulating cement or block insulation shall be used.

(1) Insulating cement shall be built-up in $\frac{3}{4}$ -in. coats to a thickness equal to the insulation on adjacent piping, by the same method as used in Fig. 8.

(2) Blocks of a thickness $\frac{1}{2}$ in. less than the insulation on adjacent piping shall be carefully fitted and wired securely in place. A $\frac{1}{4}$ -in. coat of insulating cement shall then be applied, troweling it well into the cracks between adjacent blocks.

Application of finish—Blanket-type pipe insulation located indoors and not exposed to moisture or abrasion shall be finished as described below. (See Fig. 10.)

(1) Pipes, valves, flanges, and fittings shall be finished, when specified, with a canvas jacket sewed or pasted over a layer of flameproof paper, $\frac{1}{8}$ -in. thick asbestos paper, or a $\frac{1}{4}$ -in. coat of insulating or finishing cement. If sewed, stitches shall be spaced not more than $\frac{1}{2}$ -in. apart, with seams located where least visible.

(2) Pipes, valves, flanges, and fittings may be finished with asphaltic finish when specified. A $\frac{1}{4}$ -in. coat of insulating or finishing cement shall be applied and when the cement has thoroughly dried, 1-in. galvanized-wire netting shall be stretched tightly over the surface and wired in place with No. 16-gage galvanized wire. Asphaltic finish shall then be applied sufficiently thick (approximately $\frac{1}{4}$ in. thick, wet) to provide a minimum dry thickness of $\frac{1}{8}$ -in.,

troweling it well into the wire netting.

(3) When a roofing-felt finish is specified it shall be smooth-surface asbestos asphalt-saturated, weighing not less than 55 lb per roll of 108 sq ft. Seams shall be lapped at least 2 in. against the weather and when specified, shall be sealed with lap cement. The roofing-felt jacket shall then be secured in place with copper wires or galvanized bands spaced on specified centers.

Blanket-type pipe insulation located outdoors or exposed to moisture or abrasion shall be weatherproofed as described below.

(1) Pipes, valves, flanges, and fittings shall be finished with a sheet-metal jacket, roofing-felt, or asphaltic finish, as specified.

(a) Sheet-metal jackets shall be no lighter than No. 28 gage, single or double galvanized. Seams shall be lapped 2 in. against the weather and secured in place with $\frac{1}{2}$ - or $\frac{3}{4}$ -in. galvanized metal bands, machine-stretched and crimped, on specified centers.

(b) When a roofing-felt finish is specified it shall be smooth-surface asbestos asphalt-saturated, weighing not less than 55 lb per roll of 108 sq ft, applied as above.

(c) Pipes, valves, flanges, and fittings may be finished with asphaltic finish when specified, applied as above.

Molded-Type Pipe Insulation

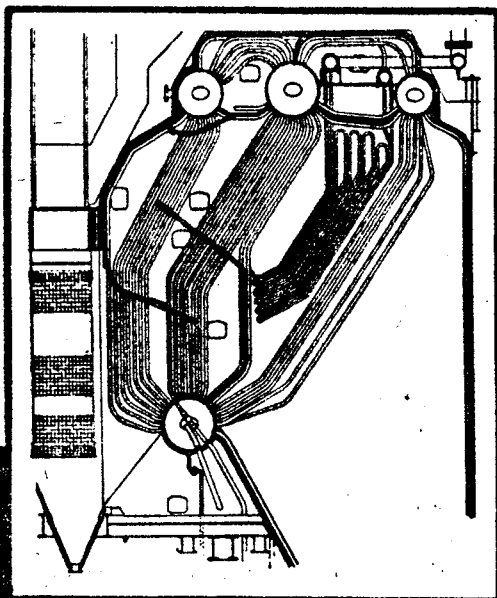
Installation on pipes—Molded-type mineral wool pipe insulation of specified thickness (see Table III) shall be applied in sectional or segmental form, of single- or double-layer construction, as specified. At flanges, pipe covering shall be spaced a sufficient distance from the flanges to permit easy removal of bolts when flanges are opened.

(1) Adjacent pieces of sectional pipe insulation shall be butted closely together and banded in place. (See Fig. 12.)

(2) Segmental pipe insulation should be secured in place with separate loops of No. 16-gage galvanized wire, spaced on 8- to 12-in. centers, depending on the pipe size and insulation thickness. Ends of wire loops shall be bent over and pressed into the insulation, leaving no sharp projections. Insulating cement shall then be troweled well into any cracks between adjacent segments. (See Fig. 13.)

(3) Double-layer pipe insulation, either in sectional or segmental form, shall be applied with circumferential and longitudinal joints staggered, omitting the canvas jacket between layers. The first layer shall be wired in place with separate loops of No. 16-gage galvanized wire spaced on 8- to 12-in. centers. The second layer shall be applied snugly over the first layer and secured in place. (See Fig. 14.)

Installation on valves, flanges, and fittings—Valves, flanges, and fittings shall be covered with insulating ce-
(Continued on page 162)



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Insulation— How to Install It

(Continued from page 100)

ment, block insulation, or molded-type pipe insulation, as specified.

(1) Insulating cement shall be built up in separate coats no greater than $\frac{3}{4}$ in. thick, to a thickness equal to the insulation on adjacent piping by the method shown above for insulating cement and shown in Fig. 8. (See Fig. 15)

(2) Blocks of a thickness $\frac{1}{2}$ in. less than the insulation on adjacent piping shall be carefully installed on large fittings (approximately 4 in. and up in diameter) and secured in place with No. 16-gage galvanized wire. A $\frac{1}{4}$ -in. coat of insulating cement shall then be applied, troweling it well into the cracks between adjacent blocks. (See Fig. 16.)

(3) Molded-type pipe insulation may be used to insulate flanged couplings. Rings of sectional pipe covering $1\frac{1}{2}$ to 2 in. wide should be wired in place on each side of the flange, selecting an insulation thickness that will provide an outside diameter equal to or greater than the flange diameter. A piece of sectional pipe insulation long enough to cover the flange should then be banded in place. (See Fig. 17.)

Application of finish located indoors.—Molded-type pipe insulation located *indoors* and not exposed to moisture or abrasion shall be finished with a canvas jacket.

(1) The factory-weight canvas jacket furnished shall be drawn tight, and smoothly pasted down at all side and end laps. Factory bands shall be applied, one binding the adjacent ends and one at the center of each section.

(2) When extra-weight canvas jacket is specified, the factory-weight canvas and bands (if furnished) shall be omitted. The pipe insulation shall be enclosed in 40-lb rosin-sized paper, over which the specified 6- or 8-oz canvas jacket shall be sewed neatly in place with stitches spaced not more than $\frac{1}{3}$ in. apart, with seams located where least visible.

Insulation on flanges, valves, and fittings located *indoors* or not exposed to moisture or abrasion shall be covered with a $\frac{1}{4}$ -in. coat of insulating or finishing cement. Portland cement may be added to provide a harder finish.

(1) When specified, a 6- or 8-oz canvas jacket shall then be sewed or pasted neatly over the dry cement. Sewed canvas jackets on valves, flanges, and fittings shall be made continuous with the canvas on adjacent piping by overlapping or blind stitching.

Application of finish located outdoors.—Molded-type pipe insulation and fittings located *outdoors* or exposed to moisture or abrasion shall be provided with a weather-proof protective finish in the same general manner as specified for blanket-type pipe insulation.



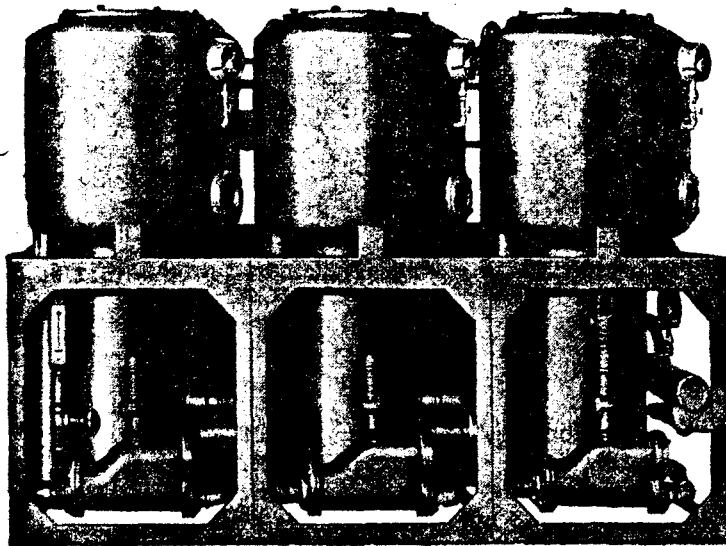
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Guides for Painting

When specified, insulation finishes shall be painted for identification purposes in accordance with "Scheme for the Identification of Piping Systems," issued by the American Standards Association (A13-1928). The application of paint should be deferred until the insulated equipment has been operated at the design temperature for a sufficient length of time to thoroughly dry out all components of the installation.

When weatherproof finish of the emulsified-asphalt type is to be painted, it should be primed with at least one coat of aluminum paint before applying lead-in-oil paint. Asphalt-base paint may be used directly over the asphaltic finish when a black color is specified.

Canvas should be given at least one coat of glue size followed by two coats of lead-in-oil paint. Galvanized metal is not ordinarily painted immediately following application. If painting is required, it should be done in accordance with manufacturers' directions. Insulating cements and finishing cements ordinarily dry to a light color, and may be painted with a nonpenetrating paint such as aluminum.

Maintenance

In order to maintain high thermal efficiency in conjunction with long insulation life, the following recommendations are made:

(a) Inspect all insulation jobs periodically, particularly those located outdoors or exposed to moisture, vibration, or abrasion.

(b) When equipment is moved, or if for other reasons the finish of the insulation is damaged or becomes loose, repair or replace as required to prevent deterioration.

(c) For advice on problems in connection with any specific insulation application, consult the manufacturer or the contractor who applied it.

Polarized Light Servo-System

(Continued from page 95)

A small d-c generator is attached to the shaft of the motor and its output voltage is applied through capacitor (C_1) between the grid and cathode of tube (2). The voltage (e) generated by this generator is proportional to the speed (w) of the secondary shaft. For the frequencies encountered the current through C_1 , and therefore the voltage across the grid resistor of the tube (2), is proportional to $\frac{de}{dt}$, and is therefore proportional to $\frac{dw}{dt}$, the acceleration of the shaft. Thus, the condition of balance of the two light beams is anticipated, and the system is stabilized and remarkably free from the hunting or oscillation commonly experienced in servo systems.

It will be noted that a single lamp is used as a light source for both beams of light so that any changes in the light output due to aging, darkening of the